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ABSTRACT

The mathematics education goals for Montgomery County Public Schools are listed in this public policy statement. This is the second of two booklets describing the entire school system's mathematics program, and grades nine through twelve are focused upon. The basic skills in mathematics that the school system wants each child to attain are the ability to perform computations, solve common problems of mathematics and logic, and understand the structure of mathematics so it can be a useful tool in daily living. A chart of the possible patterns of study in grades seven through twelve is provided. Descriptions of the high school mathematics program and courses offered are included. (MP)

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Program of Studies

MATHEMATICS 9-12

MONTGOMERY COUNTY PUBLIC SCHOOLS
Rockville, Maryland

SPRING 1979

SE 031 744

PROGRAM OF STUDIES

MATHEMATICS, GRADES 9-12

Department of Instructional Planning and Development
Montgomery County Public Schools
Rockville, Maryland

Spring 1979

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Rockville, Maryland

FOREWORD

CURRICULUM AND INSTRUCTION

Curriculum may be defined as the general prescription for what teachers should teach and students should learn. In the Montgomery County Public Schools, the *Program of Studies* embodies this prescription. The *Program of Studies* includes the prescribed elements of programs and courses, including course titles, codes, instructional objectives, content descriptions, prerequisites, time allotments, credit values, and a point of view for instruction in each subject area. Based on the MCPS Goals of Education* these prescribed elements constitute the countywide framework within which schools develop and carry out instructional programs tailored to local needs. The relationship of curriculum to instruction in the MCPS, therefore, is that of the more general to the more specific. The *Program of Studies* provides specifications, sets limits, and indicates directions. It has direct and indirect implications for the selection and organization of content, patterns of learning and teaching, and evaluation of outcomes. However, the fulfillment of these specifications and implications is determined at the individual school level. The MCPS instructional program is, therefore, the interaction of the *Program of Studies* framework with the efforts of the individual schools. An appreciation of this interaction is necessary for an understanding of the place of the *Program of Studies* in the work of the schools.

The framework represented by the *Program of Studies* makes possible a unified countywide instructional system which at the same time permits the flexibility of programming required in a large and diverse county. At points, the *Program of Studies* may prescribe instruction very specifically. This may happen with regard to a socially sensitive topic such as sex education, or it may result from the rigorous requirements of establishing an instructional system in mathematics. But this degree of specification is unusual in the *Program of Studies* inasmuch as its level of prescription is generally represented by the instructional objectives it contains for all programs and courses. Instructional objectives are general statements of what the student should attain and are thus appropriate for all students taking a given program or course. Performance objectives are more specific statements of what the student should attain. Formulated or adopted by teachers in relation to the instructional objectives, performance objectives are used in planning classroom instruction. They are thus specific enough to form the basis of day-to-day work and of evaluation of the student's progress. In this movement from instructional to performance objectives, the teacher finds the guidance and the leeway to plan for students of a wide variety of needs and abilities. An examination of the illustrative performance objectives found in instructional guides and in teachers' lesson plans makes clear how great this range is.

An additional means of differentiating instruction which becomes increasingly important at the upper grade levels is provided by elective courses. The use of electives to provide for students of varying abilities and interests differs considerably from subject to subject. Almost all subjects have courses or course sequences which provide for enriched content and advanced or specialized work. Some provide for accelerated movement; some offer additional courses for advanced or specialized work; and some have differentiated paths among required and/or elective courses. The structure of each subject area and the ways by which it employs electives to provide for diverse student needs is indicated in the Grades 9-12 portion of the program description for each subject.

Information regarding each subject area appearing in the *Program of Studies* is presented, when appropriate, as two sections — one for Grades K-8 and one for Grades 9-12. For those subject areas spanning Grades K-12, both sections must be consulted for a full description of the program.

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*Adopted February 12, 1973 by the Board of Education of Montgomery County, Maryland

Each subject area section, whether K-8 or 9-12, has the following subsections: Point of View, General Information, Description of Program, and Instructional Guides.

The Point of View subsection includes reasons for studying the subject, general outcomes sought, ways in which the area of study is pursued in MCPS, and relationships to other subject areas. It also explains how students of varying abilities and interests in the subject are provided with differentiated performance objectives. An explanation of how study of the subject fulfills one or more of the MCPS Goals of Education* is included either in the Point of View subsection or as General Information. For those subject areas spanning Grades K-12, the Point of View is identical in both the K-8 and 9-12 sections.

The General Information subsection includes an explanation of how study of the subject fulfills the MCPS Goals of Education (unless this explanation has appeared in the Point of View) and how it is organized for instruction. Information is given about subject area tests required by the county or state and about federal and state involvement when it is important or distinctive for the subject area. Information about the fulfillment of graduation requirements, Grades 9-12, is also given in some detail for those subjects in which specific requirements exist. Other information specific to the subject also appears.

The largest portion of each subject area section is the Description of Program. It describes the program and supporting courses, identifies the instructional objectives for each, and includes any other prescribed or pertinent elements. For Grades 9-12, this subsection is divided into a List of Courses and a Description of Courses. The List of Courses gives a brief view of subject offerings at this level and serves as a table of contents to the subsection. The course descriptions, along with the narrative material and instructional objectives for each course, give course title, level, length, code, credit value, and prerequisites (if any).

At the end of each subject area section, there appears a list of pertinent MCPS instructional guides. This subsection is amplified to include existing annotated bibliographies, scope and sequence charts, or other such instructional materials in the subject which may have been prepared by MCPS staff.

USE OF THE PROGRAM OF STUDIES

The *Program of Studies*, as the curricular framework for the MCPS, promotes learning through a convergence of educational efforts. Students, teachers, administrators, parents/guardians, and other members of the community use the *Program of Studies* in a variety of ways to achieve the common goal of effective education.

A curriculum stated in terms of general (instructional) objectives informs the *student* of what the school intends him/her to learn and makes it easier to participate in setting specific performance objectives with teachers. Increase in learning efficiency is more apt to take place when a student knows the goal of learning. The student is also more apt to make a commitment to successful learning when at appropriate times he/she is able to select instructional methods and materials. Finally, the student's sense of achievement is reinforced when progress can be noted in the gaining of objectives.

The *teacher* who is familiar with the *Program of Studies* can be more effective in conferring with parents/guardians as well as being in a stronger position to establish specific teaching objectives, plan lessons, select instructional materials, and assess learning progress and teaching functions.

The *school principal* uses the *Program of Studies* as an administrative guide in its listing of approved courses, titles, and codes. The administrator can also deepen staff and community understanding for the

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total educational program as the *Program of Studies* is employed in teacher conferences, faculty and department meetings, and parent/guardian meetings. School effectiveness can be enhanced as the principal organizes people and resources to help learners gain the stated ends of instruction.

Learning outcomes and other information included in the *Program of Studies* give *parents/guardians and other members of the community* information useful to them. They can better understand the instructional program for their elementary school children and advise secondary school youth in course selections. Knowledge of the *Program of Studies* also enables families and other community members to communicate more effectively with their children, teachers, and school administrators.

CURRICULUM CHANGE AND MODIFICATION OF THE PROGRAM OF STUDIES

The curriculum of any public school system must reflect the continual change of the society of which it is a part. As the MCPS curriculum changes, the *Program of Studies,* which establishes the MCPS curriculum in printed form, must be modified accordingly.

In MCPS, a proposal for a new or revised program or course can originate with any individual or group in the community or school system. The staff of the Department of Instructional Planning and Development encourages, coordinates, and assists the development of such proposals. In general, the staff has responsibility for modification of curriculum as required by state and local law and policy, and for continual assessment of the need for curriculum change. Procedures for effecting changes in curriculum and the *Program of Studies* are specified in MCPS Regulation 345-1, "Development and Approval of Curriculum and Supporting Materials." These procedures first state the involvement of community and school personnel in the initiation, development, review, and tryout of proposed curriculum changes; describe the role of the Council on Instruction as a reviewing and recommending body for the superintendent; and identify the final steps of approval by the superintendent and the Board of Education. The regulation also cites relevant portions of these Board of Education policies and Maryland public school laws upon which its procedures rest.

STATE AND FEDERAL GOVERNMENT IN RELATION TO THE CURRICULUM

The major influence of the Maryland State Department of Education upon local curriculum has traditionally been through the MSDE's specification of the requirements for graduation from high school. (These graduation requirements and other provisions for earning credit are summarized on page vii.) Two newer and equally important MSDE influences stem from a state educational accountability law* and the currently evolving Project Basic.**

The Maryland Educational Accountability Act imposes several requirements in its implementation of statewide accountability. These include the establishment of goals and objectives in, but not limited to, reading, writing, and mathematics at three levels — state, school system, and individual school. The goals and objectives at the system level must conform with those established at the state level, and those established by individual schools must conform with those of the local system and the state.

Also required by the Act is a school-by-school survey of the current status of student achievement in relation to established objectives, the development of programs by each school for meeting its own needs, and the establishment of evaluation procedures for determining the effectiveness of these programs. Regular reevaluation of programs, goals, and objectives is also a stipulation of the Act.

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*Article 77, Section 28a, of the *Annotated Code of the Laws of Maryland* was passed during the 1972 session of the Maryland General Assembly. The law has come to be called the "Educational Accountability Act."

**See "The Comprehensive Plan Maryland Competency-Based Prerequisites for Graduation," a publication of the Project Basic Office of the Maryland State Department of Education, 1978.

The state plan for implementation of the Accountability Act* specified that, effective the spring of 1974, the Iowa Test of Basic Skills and the Cognitive Abilities Test would be given to all pupils in Grades 3, 5, and 7. Use of these tests has given rise to concerns about the limitations of nationally norm-referenced tests and the small part of the MCPS curriculum that is measured by the ITBS. As a result, the Maryland State Board of Education has adopted a new schedule of assessment which includes the use of the Maryland Functional Reading Test and the Maryland Functional Mathematics Test in the secondary grades. These two tests, developed at the state level, are criterion-referenced tests. This means that they test specific skills or information without regard to how well similar student populations do on a given test item. Students who pass these tests in the ninth grade will not be tested again in connection with this program. Those who fail either test will receive appropriate instruction and retesting.

Through its Project Basic, the Maryland State Board of Education is reaffirming its responsibility for establishing statewide educational standards and stating its commitment to the development of behaviors basic to effective adulthood.** The state board specified five areas of human activity in which students should develop skills and attitudes for life-functioning. The five areas and their definitions as stated in the paper are:

A. Basic Skills — All people must be able to read, write, and calculate.

B. Survival Skills — Schooling should equip all public school youth with these kinds of fundamental skills: consumer, parenting, interpersonal relations, mechanical, and personal finance.

C. World of Work — Schooling should lead to securing employment upon graduation or post-secondary education. All public school youth should be made aware of the options and opportunities of the world of work without racial or sexual bias.

D. World of Leisure — Schooling should help the student become involved in creative and healthful lifetime activities.

E. Citizenship — Citizenship should include becoming involved in the electoral process, participating in local civic affairs, and understanding the system of justice.

To implement this action of the Maryland State Board of Education, State Superintendent of Schools David Hornbeck established the Project Basic Office. Its staff is currently involved in identifying the basic competencies in the five areas. It is also to design and develop instructional activities for the five areas of human activity, develop assessment measures to certify student acquisition of the specified competencies, and coordinate the statewide implementation of minimal competencies as a prerequisite to graduation. The project is to be fully implemented by 1982.

The impact upon the MCPS curriculum of the educational accountability and the competencies programs is as yet difficult to calculate. In one sense, the impact may not be great because the objectives of the accountability program (and, it is anticipated, the competencies of Project Basic) are to a large extent already included in the MCPS curriculum. References to the impact of the educational accountability law on specific portions of curriculum are included in the *Program of Studies* within the Information sections of the descriptions for Reading, English Language Arts, and Mathematics. On the other hand, these two state programs may have a significant impact on curriculum emphasis and

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*See the "Maryland Handbook on the Accountability Assessment Program, Maryland State Department of Education, Adapted to MCPS Test Administration Procedures," issued by the MCPS Department of Pupil and Program Appraisal, February 1, 1974.

**See *The Mission of Schooling*, Maryland State Board of Education, January 1977.

balance. They could affect time allotments within and among subjects and courses and thus affect even the definition of the subjects and courses themselves. How these statewide programs are developed and how MCPS students perform on the required evaluations will determine the impact of these programs upon curriculum. They are certain to have impact upon instruction and probably even more impact on evaluation procedures.

Federal and other state involvement in curriculum is mentioned in the descriptions of those subject areas where it is found, e.g., health education and some of the vocational education subjects.

TIME ALLOCATIONS AND GRADUATION REQUIREMENTS

In the following chart, time allocations are shown for subjects Kindergarten through Grade 8. The allocations are given in minutes per week, and school administrators are expected to use them in establishing program balance.

Subject	K	Grades 1-2	Grades 3-6	Grades 7-8
English Language Arts/Reading	200	700	475	225
Mathematics	75	200	225	225
Music	100	100	100	75
Physical Education	125	150	150	225
Science	75	125	225	225
Social Studies	75	125	225	225
Home Economics and Industrial Education	—	—	—	75
Electives				225
Total	750	1500	1500	1575

The MCPS Policy on the Middle School directs the school system to provide "a curriculum based on the developmental needs of pre- and early adolescents which places primary emphasis on acquisition of basic skills but also provides a wide range of exploratory and enrichment experiences."* Middle schools are organized into interdisciplinary teaching teams which provide opportunities for flexible student grouping and scheduling. Therefore, daily, weekly, and master schedules in middle schools will not be characterized by fixed time intervals for each subject area.

New standards for high school graduation were enacted by the Maryland State Board of Education on November 27, 1974, and became effective for students entering ninth grade in the fall of 1975. These standards thus become effective for all students in Grades 9-12 in the school year 1978-79. The standards define a unit of credit; specify credit requirements for graduation; and list several provisions for earning credit and several alternatives to four-year enrollment. MCPS Regulation 310-3, "High School Graduation Requirements," includes these state graduation requirements, the policy of the Montgomery County Board of Education with regard to them, and guidelines for their implementation.

*The MCPS Policy on the Middle School, adopted December 13, 1977

With exceptions specified under "Alternatives to Four-Year Enrollment," the MCPS student must, beyond the eighth grade, complete four years of approved study and earn a minimum of 20 credits. Twelve and one-half of these credits must be in the areas specified below. The additional seven and one-half elective minimum units may be chosen from offerings in any curricular area.

English Language Arts	4 credits
Social Studies	3 credits (One must be United States History; and one must deal with contemporary issues including local, state, and national governments.)
Science	2 credits
Mathematics	2 credits
Physical Education	One-half credit, required in Grade 9, and one-half credit sometime during Grades 10-12
Physical Activity*	Two semesters of physical activity sometime during Grades 10-12 (One-half credit of elective physical education fulfills the requirement of two semesters of physical activity.)
Health Education	One-half credit, required in Grade 9

The several provisions listed by the state for earning credit in addition to regular school day and school year programs are summer school, evening school, correspondence courses, tutoring, examination, and work study programs or experience outside the school. On pages 10 and 11 of MCPS Regulation 310-3, the Montgomery County Board of Education guidelines for each of these provisions are shown. The provision on credit by examination is being implemented as examinations appropriate to MCPS courses can be developed. During the 1977-78 school year, such examinations were given for Algebra 2; Trigonometry; and English, Grade 12.

The alternatives to four-year enrollment are an accelerated twenty-credit program; an early college admission program; early admission to approved vocational, technical, or other post-secondary school; and a job entry training program. To receive a high school diploma through any one of these alternatives, the MCPS student must receive approval for waiver of the four-year enrollment requirement. MCPS Regulation 310-3 includes the steps for requesting and receiving approval of the waiver. In addition to reading the regulation, which is available in all school offices and in school instructional materials centers, students and parents/guardians should consult local school counselors with regard to any of these provisions or those concerning earning credit outside the regular school day and year.

INTERAGENCY PROGRAMS

As has been stated, the *Program of Studies* prescribes the curriculum for all MCPS students by allowing for much differentiation of instruction. Instructional alternatives are created by varying content, assessment criteria, pace, and the pattern of courses the student takes. Beyond this differentiation, special instruction and other services are provided for handicapped students. In order to provide programs for all handicapped students, MCPS coordinates services with local and state agencies and other resources.

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* See pages 3-4 of the Physical Education Grades 9-12 section of the *Program of Studies*.

For those students who are most severely handicapped, including those who are placed outside of MCPS schools, the MCPS curriculum is adapted as required to meet the limitations of the students. Information about programs for these students is available from the Placement Unit of the Department of Interagency Programs, MCPS Office of Continuum Education.

AVAILABILITY OF INSTRUCTIONAL MATERIALS

The instructional guides listed at the end of each subject area section of the *Program of Studies* are on file in school Instructional Media Centers and in the Professional Library (formerly the Educational Materials Laboratory) at the Educational Services Center. They may be ordered from the Division of Supply Management, Department of School Services, MCPS Office of Supportive Services, which maintains a list of the guides stocked in its warehouse.

Occasionally, there will be a need in a subject area for publication of some supplemental instructional material such as a scope and sequence chart or a bibliography. If such exist, they are also listed at the end of the subject area section.

The Department of Instructional Resources, MCPS Office of Program Development, maintains files of approved textbooks and text materials and of approved films. A list of approved textbooks and text materials is published annually. Questions regarding this list should be addressed to the Division of Instructional Materials, Evaluation and Selection. A list of approved films is published periodically, and questions regarding it should be addressed to the Film Library of the Division of Instructional Materials, MCPS Department of Instructional Resources.

The Goals of Education

Adopted by the Board of Education — February 12, 1973

The goals of education for the Montgomery County Public Schools are set forth in this statement of public policy to guide the school system in developing, implementing, and improving educational programs for its students. This statement outlines those goals considered by the citizens of the county as most important for the education of their children in public schools and for which the citizens will hold the school system responsible and accountable.

The school system has the primary responsibility for some of these goals. For others, it shares that responsibility with the home and other community institutions.

The extent to which these goals can be realized will depend upon the endorsement by and continuing commitment of the school system staff, students, parents, and the community. With broad endorsement and wide support, the Montgomery County Public Schools will continue its development to serve its students and community in the most effective way possible.

Education is a process that encompasses the total experiences of each individual throughout a lifetime of formal and informal learning. The school program, as a keystone in this process, should provide opportunities and encouragement for students to acquire knowledge, to explore ideas, to ask questions, and to seek answers that will lead to sound and useful conclusions.

The probability of success motivates students to learn. Each school must create a program and maintain a climate in which every student has opportunities for success. Each individual is unique, and the school shall encourage that uniqueness. The school should help the student understand his [/her] values and the values of others.

The school program, while developing the skills of learning, should be based on the study of broad human concerns, flexible enough to deal with changing concerns and at the same time related to the needs, interests, and concerns of each student. The program should offer opportunities for decision-making. It should help the student develop the capacity to learn throughout his [/her] lifetime, to respond to and understand other human beings, and to accept full responsibility for the results of his [/her] actions.

Therefore, the Montgomery County Public Schools dedicates itself to provide the opportunity, encouragement, and guidance to make it possible for every child to attain the following goals of education:

ACADEMIC SKILLS

The fundamental responsibility of the school is to develop programs that enable each child to acquire those skills basic to all learning. The achievement of all other goals depends upon the success of the school in ensuring that each student, according to his [/her] own abilities, attain the following basic skills:

- **Reading:** The ability to read and comprehend written material and relate it to other knowledge
- **Composition:** The ability to write with precision, clarity, and acceptable usage, whether to inform, inspire, or persuade
- **Listening and Speaking:** The ability to listen attentively and with understanding and to speak with confidence and effectiveness, whether from written material or extemporaneously
- **Mathematics:** The ability to perform computations, to solve common problems of mathematics and logic, and to understand the structure of mathematics so it can be a useful tool in daily living
- **Study:** The development of basic study skills so that he [/she] may acquire knowledge efficiently
- **The Arts:** The development of some of the basic disciplines and skills in the performing and creative arts to be used throughout his [/her] life for communication expression, and enjoyment
- **Observation:** The ability to identify and differentiate elements of the world around him [/her] as they are useful in personal, academic, and artistic pursuits

PHYSICAL DEVELOPMENT

Each person matures physically at a different rate and possesses differing capabilities. The school has the obligation to help each student:

- understand the biological functioning of his [/her] body
- make the best both of physical talents and limitations
- develop good health habits, skills, and interests to maintain his [/her] body in optimum condition throughout his [/her] lifetime

INTELLECTUAL DEVELOPMENT

In addition to acquiring academic skills, each individual should develop his [/her] intellectual capabilities to the fullest extent possible. Therefore, the school will encourage each pupil:

- to think creatively
- to reason logically
- to apply knowledge usefully
- to deal with abstract concepts
- to solve problems

THE INDIVIDUAL AND SOCIETY

Every person must learn to live in a society. The school must help each student develop an understanding of [people] and of how the individual depends upon others and they on him [/her]. This requires that each student gain:

- knowledge of himself [/herself] and the characteristics, needs, and desires he [/she] shares with others
- sensitivity to others and their ideas, and the ability to act responsibly in various situations
- the ability to function productively as a member of a group
- familiarity with the legal, moral, ethical, and cultural heritages of his [/her] and other societies
- knowledge of the various political systems and philosophies of the world

SCIENTIFIC UNDERSTANDING

[We] must exist in the natural world. The school must help each student understand nature's impact on [us] and [our] impact on nature. This requires that each student gain:

- knowledge of natural phenomena and their effect on [people]
- understanding of scientific advances and their part in modern technology
- understanding of the scientific method
- appreciation of the ways in which the application of scientific principles can improve the quality of life while preserving the natural order

AESTHETIC EXPRESSION

[We], to realize [our] full potential, must be able to sense and appreciate beauty in the world around [us], whether created by nature or by [people]. The school must help each student gain:

- knowledge of the nature of the creative performing arts
- experience with a wide variety of art forms
- a perspective for developing his [/her] own aesthetic criteria and tastes
- understanding of the contribution of the arts to human communication

CAREER DEVELOPMENT

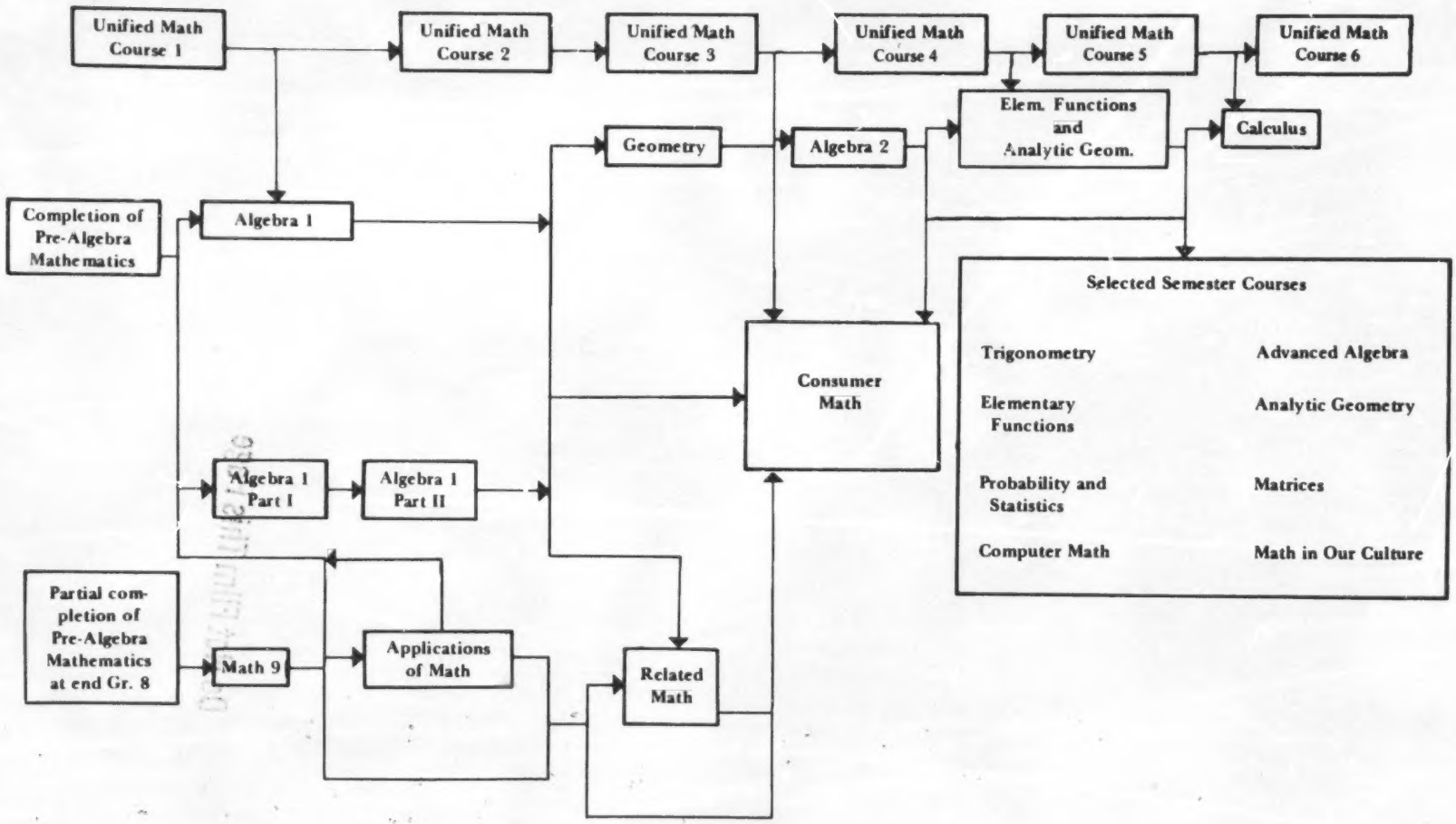
Productive and satisfying work enriches [our lives]; and with increasing leisure time, many people will use various occupational skills for avocational purposes as well. The school must help each student gain:

- knowledge and appreciation of the wide variety and interrelationships of occupations in modern society
- opportunities to explore potential occupations in relation to personal aptitudes and interests, unrestricted by stereotypes of sex, race, or socio-economic level
- the knowledge, skills, and abilities that enable him [/her] to secure satisfying employment, embark upon further training and education in a chosen career field, and adapt occupational talents to changing job demands and opportunities

COMMITMENTS

The Board of Education and the staff of the Montgomery County Public Schools must create and maintain an educational environment that promotes the attainment of these goals by all students. Toward this end, therefore, the public schools make the following commitments to the citizens of Montgomery County:

- *To attract and retain the most qualified and best trained staff possible through dynamic programs of recruitment, supervision, and continuing in-service training and staff development opportunities*
- *To develop and implement a comprehensive and flexible instructional program to achieve the aforementioned goals and to provide the facilities, materials, and equipment needed to enhance the effectiveness of the program*
- *To evaluate the effectiveness of the instructional program continuously, and regularly report the findings to students, parents, staff, and the community*
- *To adopt new and different approaches when it is determined that they will contribute more effectively to the fulfillment of the goals*
- *To encourage a continuing dialogue with the entire community, making every effort to communicate needs and achievements, and to be responsive to the needs and aspirations of the school community*
- *To utilize facilities and staff, in cooperation with other agencies, in the development of preschool, community school, and adult education programs that will meet the continuing educational needs of all citizens*
- *To provide an accountability procedure for informing county citizens of the objectives and costs of their school system and of reporting periodically on the educational investments made with their tax dollars*



MATHEMATICS PROGRAM PATTERNS CHART

MATHEMATICS, GRADES 9-12

POINT OF VIEW

A provocative activity which teachers often use with pupils at various levels is that of trying to imagine what a world without numbers would be like. Such a world is difficult to imagine. The idea of number continues to play an important role in virtually all aspects of our world; and mathematics, therefore, constitutes a program of considerable importance in the schools.

As a discipline, mathematics is truly the art and science of abstraction. Characteristics of the physical world are converted into abstract ideas and symbols; these are then manipulated through mathematical operations to produce information and theorems about less easily observed aspects of the world. Recent evidence supports the contention that children's experiences with concrete materials are vital to later conceptual development. The school program thus proceeds from the concrete to the abstract.

The concepts of mathematics acquire greater meaning when they can be applied to the world in which we live. Because the variety and extent of mathematical applications have grown so rapidly in recent years, it is impossible for any one person to be conversant with the entire field. The school program must therefore be developed so that mathematical applications are selected and presented as efficiently as possible and with the intent of challenging pupils at all levels to see mathematics as an independent discipline as well as a tool for the advancement of other disciplines.

The Montgomery County mathematics program is designed and implemented to take into account the logical and relatively sequential nature of mathematics. Equally important, too, is the realization that the rate at which individual students learn mathematics varies significantly. The mathematics program is structured to encourage various approaches which allow students to progress at their individual rates.

The pre-algebra objectives range over six areas of mathematics and are arranged according to 14 different levels of achievement. Assessment measures have been constructed for each objective so that individual progress can be measured in a variety of categories. Enrichment activities are available for both the able student and the student who needs reinforcement.

Several options are available to the student who has completed the pre-algebra objectives. Differentiated paths through a variety of courses are available to the student, as can be seen in the Mathematics Program Patterns Chart, on page xiii. Each student has available a sequence of courses which can be suited to his/her interests and abilities.

Computer literacy is addressed at several levels of the mathematics program; career information is incorporated as appropriate throughout. Consumer applications are taught as mathematical skills are developed; the mathematics of consumerism is further emphasized in an elective senior high course.

In general terms, the instructional program in mathematics should help each student to:

Develop basic skills in using the vocabulary and symbols of mathematics

Develop skills in recognizing common geometric shapes

Develop basic skills in computing

Develop basic skills in working with geometric shapes

Develop basic skills in measuring, graphing, and using tables and charts

Develop understanding of the vocabulary and symbols of mathematics

Develop understandings necessary for translating among mathematical symbols, words, and the physical world

Develop concepts related to common geometric shapes

Develop understanding of computation

Develop understanding of measurement

Develop an understanding of basic principles related to the structure of mathematics

Develop understanding and basic skills in problem solving

Apply the principles of mathematical reasoning to the solution of problems

Appreciate the significance of mathematics in daily living and its contribution to our cultural heritage

Use mathematics as needed in daily living

GENERAL INFORMATION

The objectives of the math program are compatible with the philosophy and commitment of the MCPS Goals of Education* and are specifically aligned with the Academic Skills area. The goal in this area states that the school must ensure that each student, according to his/her unique capabilities, attains the following basic skills:

- The ability to perform computations, to solve common problems of mathematics and logic, and to understand the structure of mathematics so it can be a useful tool in daily living
- The development of basic study skills so that he [/she] may acquire knowledge efficiently

The MCPS mathematics program is generally organized into two levels. Elementary and pre-algebra mathematics begins with the kindergarten program and continues until the student has completed those mathematical objectives which are prerequisites for the study of algebra, as delineated in *Elementary and Pre-Algebra Mathematics Objectives*. Beginning in Grade 7, a student may enter Algebra 1 at any time, upon demonstrating that the pre-algebra objectives have been attained. Mathematically and verbally able sixth grade students in certain schools may be selected to enter in Grade 7 the six-year secondary Unified Mathematics program.

The various sequences of courses available to students after Grade 8 or after the completion of the pre-algebra objectives are detailed in the Mathematics Program Pattern Chart found on page xi. The Unified Mathematics sequence is offered in certain schools as an alternative program for the mathematically and verbally able students; its content is developed in a spiral fashion, spanning and unifying various mathematics fields — algebra, geometries, abstract algebra, probability, trigonometry, and calculus. The accelerated traditional program ending in calculus is made available in all secondary schools as an alternative program for mathematically and verbally able students. Students who

*Adopted February 12, 1973 by the Board of Education of Montgomery County, Maryland

complete the algebra objectives in Grade 8 may follow the Algebra 1 — Geometry sequence all the way through Calculus in Grade 12. Most MCPS students enroll in Algebra 1 in Grade 9, Geometry in Grade 10, and Algebra 2 in Grade 11. Students who do complete the pre-algebra objectives but who need additional instruction and time to achieve understanding of abstract concepts of Algebra 1, may enter the Algebra 1, Part I and Part II sequence, followed by several course options. Students who by the end of Grade 8 have partially completed the pre-algebra objectives may complete these objectives in Math 9 and receive further reinforcement, if necessary, through the study of Applications of Math in Grade 10.

Any student who completes Algebra 2 may select any of the several semester course offerings grouped together on the right side of the chart on page xi. As indicated in that chart, Consumer Mathematics is available to all students in Grades 11 or 12.

The Maryland State Department of Education has constructed a Grade 7 Mathematics Test to be given annually statewide to all Grade 7 students. This test measures achievement on specified basic skills objectives. The Functional Mathematics test is mandated by the State of Maryland for all Grade 9 students; students who do not meet passing requirement on this test will be tested again in Grade 10.

Two credits of mathematics in Grades 9-12 are required for graduation in the State of Maryland. At least one of these credits must be attained through successful completion of a course attended for the required 132 clock hours. These two credits are to be earned in courses described in the mathematics program, Grades 9-12. An exception to this is that a business education student may choose credit in Business Mathematics as one of the two required mathematics credits.

The mathematics program includes the option of examination for credit in several courses. Examinations in Algebra 2, Geometry, and Trigonometry are given at prescribed times.

Approved secondary mathematics texts are listed in the MCPS *Secondary Textbook List.* Approved films are listed in the MCPS *Film Catalog.*

DESCRIPTION OF PROGRAM — MATHEMATICS

List of Courses, Grades 9-12

*Algebra 1
  *Algebra 1, Part I
  *Algebra 1, Part II
*Geometry
*Algebra 2
*Elementary Functions and Analytic Geometry
*Calculus

*Unified Math Course 3
*Unified Math Course 4
*Unified Math Course 5
*Unified Math Course 6

Math 9
Applications of Math
Related Math

*Consumer Math

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*Denotes courses for which the objectives are listed by semester

Trigonometry
Advanced Algebra
Elementary Functions
Analytic Geometry
Probability and Statistics
Matrices
Math in Our Culture
Computer Math

DESCRIPTION OF COURSES, Grades 9-12

Algebra 1 — Grades 9, 10, 11, 12
Prerequisite: Attainment of the pre-algebra objectives in Elementary and Pre-Algebra Mathematics Objectives, Bulletin 285
3100 — 1 year — 1 credit

Emphasis in Algebra 1 is on the development of an understanding of the basic structure of algebra related to the real number system; a recognition of the techniques of algebra as structures of this system; facility in applying algebraic concepts and skills; perception of the role of deductive reasoning in algebra; and an appreciation of the need for precision of language.

As techniques are developed, applications to appropriate, relevant problems are made; e.g., problems involving practical geometry, number theory, weather, air navigation, and money are included. Opportunities for enriching work in greater depth occur throughout the program.

Algebra 1 is taught as a one-year course or as a two-year course as student needs indicate; pupil placement depends on a decision made cooperatively by the student, the parent, and the school staff.

Algebra 1-A
Prerequisite: Attainment of the pre-algebra objectives in Elementary and Pre-Algebra Mathematics Objectives, Bulletin 285
3111 — 1 semester — ½ credit

Upon completion of Algebra 1-A, the student should be able to:

- demonstrate the use of the roster, rule, and graphing methods in representing sets
- compute the value of a numerical expression involving symbols of inclusion and the order of operations rules
- add, subtract, multiply, and divide directed numbers
- apply properties of equality and inequality and the concepts of additive and multiplicative inverses to solve equations and inequalities
- apply the fundamental operations to solve open sentences and word problems involving real numbers
- graph the solution sets of linear equations and inequalities
- add, subtract, multiply, and divide polynomials
- factor polynomials completely
- solve equations involving polynomials
- solve word problems involving the factoring of polynomials

Algebra 1-B
Prerequisite: Attainment of the objectives of Algebra 1 A
3112 1 semester ½ credit

Upon completion of Algebra 1-B, the student should be able to:

- rewrite a linear equation into slope-intercept forms and graph its solution set
- determine an equation of a line
- solve a system of open sentences in two variables
- solve word problems involving open sentences in two variables
- add, subtract, multiply, and divide algebraic fractions
- write radical expressions in simplest form
- solve quadratic equations
- solve equations and word problems involving irrational numbers

Algebra 1, Parts I and II
3101 (Part I) 1 year 1 credit per year (9-12)
3102 (Part II) 1 year

Algebra 1, Parts I and II, is a two-year program for achieving the Algebra 1 objectives. This program is offered for students who have satisfactorily completed necessary pre-algebra objectives but who need additional instruction and time to achieve understanding of abstract concepts. Textbooks written especially for a two-year program are provided.

Algebra 1, Part I-A
Prerequisite: Attainment of the pre-algebra objectives in Elementary and Pre-Algebra Mathematics Objectives, Bulletin 285
3103 1 semester ½ credit

Upon completion of Algebra 1, Part I-A, the student should be able to:

- demonstrate the use of the roster, rule, and graphing methods in representing sets
- compute the value of a numerical expression involving symbols of inclusion and the order of operations rules
- apply the fundamental operations to solve open sentences and word problems involving the positive rational numbers
- apply the existence and uniqueness properties, the commutative, associative, and distributive property to solve equations
- apply the properties of equality to solve open sentences and equations involving the positive rational numbers

Algebra 1, Part I-B
Prerequisite: Attainment of the objectives of Algebra 1, Part I-A
3104 1 semester ½ credit

Upon completion of Algebra 1, Part I-B, the student should be able to:

- add, subtract, multiply, and divide directed numbers
- apply properties of equality and inequality and the concepts of additive and multiplicative inverses to solve equations and inequalities
- apply the fundamental operations to solve open sentences and word problems involving real numbers
- add, subtract, multiply, and divide polynomials

Algebra 1, Part II-A
Prerequisite: Attainment of the objectives of Algebra 1, Part I
3121 1 semester ½ credit

- factor polynomials completely
- solve equations involving polynomials
- solve word problems involving the factoring of polynomials
- write radical expressions in simplest form
- solve quadratic equations
- solve equations and word problems involving irrational numbers

Geometry — Grades 9, 10, 11, 12
Prerequisite: Attainment of the objectives of Algebra I or Algebra I, Part II
3200 1 year 1 credit

Geometry is offered for those students who have achieved the student outcomes of Algebra 1. The more formal study of the logic principles forms the basis for the deductive development of geometry as a mathematical system. Relationships in the plane and in space, developed intuitively in previous years, are shown as resulting from a few basic assumptions (postulates) and from the application of logic and deductive thinking. Algebraic techniques are used throughout the course.

Geometry A
Prerequisite: Attainment of the objectives of Algebra I or Algebra I, Part II
3201 1 semester ½ credit

Upon completion of Geometry A, the student should be able to:

- demonstrate the use of logic in determining the truth values of the forms of an implication, and of disjunctions and conjunctions
- describe the uses of undefined terms, definitions, postulates, theorems, logic, and deductive and inductive reasoning in developing into a mathematical system the geometric relationships encountered in the course
- identify congruent segments and angles, and pairs of angles which are adjacent, vertical, complementary, and supplementary
- classify triangles according to the measure of their sides and according to the measure of their angles
- construct the proof of an implication by the direct method
- apply the rules for parallel and perpendicular lines and planes
- apply the rules for angle measure in triangles
- construct the proofs for theorems based on the rules for proving triangles congruent

Geometry B
Prerequisite: Attainment of the objectives of Geometry A
3202 1 semester ½ credit

Upon completion of Geometry B, the student should be able to:

- apply the rules of ratio and proportion to determine the measures of the sides of given similar triangles
- apply the Pythagorean Theorem to determine the length of any side of a right triangle
- identify the terms related to the study of a circle
- demonstrate the rules about chords, secants, and tangent segments of a circle

- perform basic geometric constructions and apply them in solving location problems on a plane and in space
- apply the rules for determining areas of polygons
- construct the solutions to problems involving the areas of a circle, segment, and sector; the circumference of a circle; and the length of arcs, radii, diameters, and chords of a circle
- apply the rules for determining lateral area, total surface area, and volume of solids

Algebra 2 — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Geometry
3300 1 year 1 credit

The content of Algebra 2 is more abstract in nature than that of previously offered courses. The beauty of mathematics and the possibilities of extended concepts and skills in algebra are the emphases, rather than practical applications and visualizations. Linear and quadratic equations and inequalities are solved; and these solutions — algebraic and graphic — are extended through the coordinate plane to systems of these equations. Logarithmic and exponential functions are examined algebraically and graphically. The graphing of the more complicated general form of the quadratic equation leads to the discovery and graphing of the conic sections.

For interested students, further work is possible in matrices and determinants, in trigonometric relations, in sequences and series, and in vector algebra.

Algebra 2-A
Prerequisite: Attainment of the objectives of Geometry
3301 1 semester ½ credit

Upon completion of Algebra 2-A, the student should be able to:

- perform the four fundamental operations with irrational numbers
- perform the four fundamental operations with complex numbers
- factor or simplify rational expressions
- distinguish between a function and a relation which is not a function
- identify and graph the equation of functions which are constant, linear, or quadratic
- use the relationship of the slopes of parallel or perpendicular lines to determine equations of such lines
- solve direct variation problems

Algebra 2-B
Prerequisite: Attainment of the objectives of Algebra 2-A
3302 1 semester ½ credit

Upon completion of Algebra 2-B, the student should be able to:

- solve quadratic equations over the set of real numbers or over the set of complex numbers
- solve quadratic inequalities over the set of real numbers and sketch the graph of the inequality
- apply synthetic substitution, the Remainder Theorem, Factor Theorem, Rational Root Theorem, Fundamental Theorem of Algebra, and the Property of Continuity to the estimation of zeros of polynomial equation
- identify the graph of a quadratic relation as circle, ellipse, hyperbola, or other
- sketch the graphs of the circle, the ellipse, the parabola, and the hyperbola from the quadratic equation which describes each
- solve problems involving systems of linear equations in two or three variables
- sketch graphs of and find solutions for quadratic-linear and quadratic-quadratic systems of equations

- multiply, divide, or simplify expressions containing real number exponents
- state equivalent exponential and logarithmic equations
- apply scientific notation, interpolation, and common logarithms to compute products, quotients, and powers

Elementary Functions/Analytic Geometry — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3400 1 year 1 credit

Elementary Functions/Analytic Geometry is a year course designed as a preparation for the calculus course. The course objectives are those as defined for the semester courses Elementary Functions and Analytic Geometry.

Elementary Functions
Prerequisite: Attainment of the objectives of Algebra 2
3421 1 semester ½ credit

The aims of this course are two-fold: first, to provide students who intend to study calculus some of the essential background (the other background essentials being gained through a study of analytic geometry); secondly, to provide students an opportunity to review and summarize the important concepts and methods from previous courses as well as to illustrate how these may be used in concert to cope with significant theoretical and practical problems.

A review of the structure of the real number system, including the completeness property and the method of mathematical induction, provides the foundation for the ensuing study of elementary functions. The concepts of relation and function are to be reveiwed. Particular attention is given in this course to the study of polynomial, rational, exponential, logarithmic, and circular functions. The study of each type of function includes a precise definition; a consideration of graphs and applications; an analysis of distinguishing and interesting features; and an identification of related tangents and slopes.

Upon completion of Elementary Functions, the student should be able to:

- develop a conclusion from a set of abstract axioms by means of the principles of inference and symbolic logic
- apply the axioms of a field to deductive development of the algebra of real numbers
- define a relation and a function
- identify and describe the more important elementary mathematical families of functions
- apply the Principle of Mathematical Induction to the development of formulas for the *n*th terms and sums of finite arithmetic and geometric series
- distinguish between and sketch linear relations and functions
- apply synthetic division, the Remainder Theorem, the Factor Theorem, and the Rational Root Theorem to find rational zeros of given functions and to prove certain numbers irrational
- apply the properties of complex numbers and of polynomials to the factorization of polynomials over the field of complex numbers
- apply the properties of tangents and slope to find the equation of a tangent to the graph of a function and the equation of a line perpendicular to a tangent
- apply the properties of exponents, limits, and convergence to graph and evaluate exponential functions
- apply the properties of inverse functions to exponential functions to develop properties of logarithmic functions
- define, sketch, and describe the properties of the six basic circular functions and of their inverses
- describe the effects of various factors upon the graphs of simple and composite circular functions
- apply fundamental circular relations to prove equations to be identities
- apply the properties of circular functions to the solution of theoretical and practical verbal problems

Analytic Geometry — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3422 1 semester ½ credit

Analytic geometry contributes to the mathematical development and background of the student in at least three important ways: it includes subject matter which is interesting and beautiful in its own right; it links algebra and geometry together into a new and unified mathematical structure by bringing powerful algebraic concepts and techniques to bear upon geometrical problems; and it develops formulas and techniques, many of which are needed for subsequent work in mathematics and in the sciences. Consequently, analytic geometry may be perceived as a mathematical structure, a method, and a tool.

Traditionally, analytic geometry has been offered as an integral (and usually a subsidiary) part of the Calculus course. However, a systematic study of the topic as a separate semester course in high school is considered suitable, feasible, and valuable, particularly to the student planning to take Calculus later.

Topics the student will study include linear equations; direction cosines; inclination of lines; the angle between two lines; directed distances; the conic sections (circles, ellipses, parabolas, and hyperbolas) in rectangular and polar coordinates; parametric equations; three-dimensional coordinate geometry; vectors; and transformations.

Upon completion of Analytic Geometry, the student should be able to:

- associate with a given locus the characteristic form of its equation
- describe, from the type form of a given equation, the nature and properties of the locus which it represents
- apply the properties of vectors to the development of proofs involving distance and direction
- apply vector properties to the development and application of the normal form of an equation of a line
- sketch graphs of equations in the polar form
- construct equations of the various conic sections, given certain properties (e.g., the center and radius of a circle)
- apply the transformations of translation and rotation to find simplified equations of the conic sections from a general equation of the form $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$
- describe the role and nature of parameters in connection with the equations of one-, two-, and three-dimensional loci

Calculus — Grade 12
Prerequisite: Attainment of the objectives of Elementary Functions and Analytic Geometry
3500 1 year 1 credit

The topics studied in Calculus are those traditionally offered in the first year of calculus in college. For some students, this course offers an opportunity for preparation for advanced placement in mathematics in college.

Calculus A
Prerequisite: Attainment of the objectives of Elementary Functions and Analytic Geometry
3591 1 semester 1 credit

The topics developed in Calculus A include limits and continuity of functions; derivatives of algebraic functions and their applications in problems involving area, volume, work; and differentiation and integration of trigonometric functions.

Upon completion of Calculus A, the student should be able to:

- apply the rules for limits of sums, of products, of quotients, of polynomials; and of a function between two functions which have the same limit when the limit is taken as the variable approaches a constant and as it approaches infinity
- apply the rules for determining the derivatives of a monomial function and for finding the sum, product, and quotient of differentiable functions
- apply the method of implicit differentiation to specific examples of the general function

$$y = u^{\frac{p}{q}}$$

- apply the chain rule for derivatives to specific examples involving composite functions
- construct the equations of the tangent line and the normal line at selected points of an algebraic function
- construct the graph of an algebraic function, listing the critical points
- identify and construct the solution of problems that call for minimizing or maximizing a function
- apply Rolle's Theorem, the Mean Value Theorem, and l'Hopital's Rule, where appropriate
- apply the Fundamental Theorem of Calculus to determine the area of a given region
- identify and compute the sum of Riemann integrals
- apply the definite integral to solve problems involving area; velocity and acceleration; volume of a solid; area of a surface of revolution; total amount of mass; and work as the product of a given force moved through a given distance
- apply the definite integral to determine the length of a portion of a curve and to determine the center of mass for a line segment, plane region, or solid
- apply formulas for differentiation and integration of trigonometric functions

Calculus B

Prerequisite: Attainment of the objectives of Calculus A

The topics developed and applied in Calculus B include derivatives and integrals of exponential and logarithmic functions; various integration techniques; convergence tests for series; Taylor's or Maclaurin's series expansion theorems; elementary differential equations; and hyperbolic functions.

Upon completion of Calculus B, the student should be able to:

- apply formulas for differentiation and integration of inverse trigonometric, logarithmic, and exponential functions
- apply the following integration techniques: substitution by change in variable, integration by parts, trigonometric substitution, integration by partial fractions
- apply the theorems on sequences to construct the limits of sequences
- apply the comparison, ratio, and integral test for convergence of a given series
- compute an approximation of a given trigonometric or logarithmic function using Maclaurin's or Taylor's series expansion
- solve first-order differential equations and second-order linear differential equations
- apply the rules of hyperbolic functions and inverse hyperbolic functions in problems of equilibrium, tension, area, volume, and center of gravity .

Unified Mathematics

This is a six-year secondary mathematics sequence offered by some schools as an alternative program for the mathematically and verbally able student. Area office personnel assist those elementary schools

which feed the junior high schools offering this program to identify sixth graders who will be able to profit by enrolling in the program. Entry into the Unified Mathematics program is made at the beginning of Grade 7 only.

Unified Mathematics is a contemporary, unified program developed at Teachers College, Columbia University. The unification of the traditional branches of mathematics is achieved by using the basic concepts of set, relation, mapping, and operation to study the basic structures of all mathematics — groups, rings, fields, and ultimately, vector spaces. These abstract concepts and structures are developed in coordination with the important realizations of these structures — number systems, geometries, probability, and later, analysis.

The third course in Unified Mathematics concentrates on the development of structures such as matrices and vector spaces as applicable to study of geometry and the algebra of polynomial and trigonometric functions. Course 4 emphasizes an in-depth study of real-valued functions, in preparation for the study of calculus in Courses 5 and 6. Course 4 also includes a study of computer programming, its applications appearing in subsequent studies throughout the program. Probability theory is also developed to include calculus applications.

Unified Mathematics, Course 3 — Grade 9
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 2
3019 1 year 1 credit

Unified Mathematics, Course 3-A
Prerequisite: Attainment of the objectives of Unified Mathematics Course 2
3030 1 semester ½ credit

Course 3 begins with a new structure, matrices, which will be used in subsequent studies. These are used to exemplify a group; a ring; and, for particular subsets, a field. Matrices are used to generate solutions to systems of equations.

Transformations are used to extend metric geometry and perpendicularity to the study of congruence and similarity.

Sets of polynomial functions are studied in a modern setting and again exemplify group and ring structures. The study is extended to the set of rational functions and a new field representation.

Upon completion of Unified Math 3-A, the student should be able to:

- perform basic binary operations with matrices
- identify the group properties in the set of matrices over the operation of matrix addition
- identify ring and field properties in certain sets of matrices over matrix operations
- solve a system of linear equations by three main techniques: substitution, Gauss elimination, and conversion to matrix form
- determine solutions to linear programs
- interpret linear programs geometrically
- apply matrices and their composition to transformations and their composition
- use isometries — reflections, slides, rotations — to determine congruence
- use dilations to determine similarities
- identify the ring structure in the set of polynomial functions over addition and multiplication of polynomials
- perform operations with the factor polynomials
- interpret set of rational functions over addition and multiplication of rational expressions as a field
- graph rational functions, identifying asymptotes whenever applicable
- perform operations with rational functions

Unified Mathemaics, Course 3-B
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 3-A
3031 1 semester ½ credit

In this semester, the previous work in probability is presented in a more formal, set theoretic form. At the same time, a concrete concept of probability theory, combinations, and permutations is developed and illustrated through diagrams and models.

A new set of functions — the circular functions — which involve previously studied geometry, arithmetic, and algebra, are developed. The Law of Sines and Law of Cosines are developed and applied.

Finally, an informal introduction to solid geometry, both affine and Euclidean 3-space, leads to the introduction of *vector spaces*, which are developed fully in subsequent courses.

Upon completion of Unified Math 3-B, the student should be able to:

- determine the outcome space and certain defined events in an experiment
- determine the combination and permutations of n objects, taken r at a time
- apply the basic uniform probability theory
- identify sensed angles and congruent, sensed angles
- determine the radian measure of a standard position sensed angle
- determine the value and graph the sine and cosine functions, defined over $[0, 2\pi]$
- apply the Law of Sines and Law of Cosines to solve triangles
- determine the sine and cosine functional values for any real number by using the wrapping function concept
- apply relationships of parallel and perpendicular lines and planes in affine 3-space
- determine the angle between two skew lines
- describe a sphere, cylinder, and cone as a set of points in 3-dimensional space and in terms of rectangular coordinates
- define, illustrate, and apply vectors in a plane
- define, identify, and calculate linear combinations, generators, bases, and dimension in abstract vector spaces
- define and illustrate subspaces

Unified Mathematics, Course 4 — Grade 10
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 3
3020 1 year 1 credit

Unified Mathematics, Course 4-A
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 3
3032 1 semester ½ credit

Essentially, Unified Mathematics, Course 4, is a course on developing and using the *function* concept, a unifying concept for previously presented ideas — domain, range, mapping, rule of assignment, etc. In Unified Mathematics, Course 4-A, some elementary real functions — polynomials, sequences and series, and circular functions — are studied; and computer programming is introduced, its use to appear at various points throughout the remainder of the program.

Upon completion of Unified Mathematics, Course 4-A, the student should be able to:

- apply the basic techniques for using computers in mathematical problem solving
- compare sequence and series; convergent and divergent sequences; geometric and arithmetic sequences
- use mathematical induction to verify given theorems

- compute the sum of the first n terms of a defined arithmetic or geometric sequence
- apply mathematical models in a variety of problem settings; e.g., problems involving work, variations, distances, mixtures, etc.
- approximate solutions to polynomial equations by use of computer programs
- solve quadratic equations, over the set of complex numbers, by use of the quadratic formula
- graph quadratic functions
- use the discriminant of the quadratic formula to determine the kinds and number of solutions
- solve narrative problems involving quadratic equations
- solve system of linear-quadratic and quadratic-quadratic equations
- solve polynomial equations, using the Factor Theorem, Rational Root Theorem, Remainder Theorem, and synthetic substitution
- solve radical equations
- perform basic operations and simplify exponential expressions with rational or real coefficients
- distinguish between exponential and logarithmic functions
- use exponential functions as models of growth or decay phenomena

Unified Mathematics, Course 4-B

Prerequisite: Attainment of the objectives of Unified Mathematics, Course 4-A

3033 1 semester ½ credit

Course 4-B continues the development of logarithmic, exponential, and the circular functions. Conditional probability and the Total Probability Theorem are investigated. Finally, vector spaces and their properties are further developed.

Upon completion of Unified Mathematics, Course 4-B, the student should be able to:

- use logarithmic tables and interpolation to perform computations
- use logarithms to solve exponential equations
- define and use the function $f(x) = e^x$, where $e = \lim_{x \to \infty} (1 + \frac{1}{x})^x$, $x \in R$
- graph the six circular functions and their inverses
- verify and use basic trigonometric identities
- solve trigonometric equations
- express complex numbers in trigonometric or polar form
- apply De Moivre's Theorem
- apply conditional probability formulas to everday situations
- distinguish between dependent and independent events
- apply the Total Probability Theorem
- use vectors and vector spaces as models of physical situations involving forces, velocities, displacements, etc.
- represent lines and planes in parametric and nonparametric form, in two-space or three-space dimensions
- apply inner product of vectors to determine lengths of vectors and measure of angles between two vectors

Unified Mathematics, Course 5 — Grade 11
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 4
3021 1 year 1 credit

Unified Mathematics, Course 5-A
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 4
3034 1 semester ½ credit

The primary emphasis in Unified Mathematics, Course 5 and Course 6, is the study of calculus. In Unified Mathematics, Course 5-A, the basic concept of the derivative is developed. The notion of continuity leads to that of limit, contrary to the traditional limit continuity approach. The concept of limit and that of linear approximations are used to develop the concept of the derivative.

Upon completion of Unified Mathematics, Course 5-A, the student should be able to:

- describe the continuity of a function at a point by the use of the $\delta-$, $\varepsilon-$ neighborhood concepts or by use of a continuity diagram
- identify points of continuity or discontinuity of a given function
- apply the theorems on the continuity of the sum, difference, product, quotient, or composition of functions, over a subset of real numbers
- apply the Boundedness, Minimum-Maximum Theorem and the Intermediate Value Theorem
- apply the theorems on limits of sums, differences, products, quotients, or composition of real functions as the variable approaches a constant or infinity
- apply the Linear Approximation Theorem
- interpret the derivative of a function at a point as the slope of the line tangent to the function at that point; as instantaneous rates of change: velocity, acceleration
- apply the theorems on differentiation of the sum, difference, product, or quotient of differentiable functions
- apply the chain rule for determining the derivative of the composition of functions

Unified Mathematics, Course 5-B
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 5-A
3035 1 semester ½ credit

In Unified Mathematics, Course 5-B, applications of the derivative are emphasized in investigating algebraic functions. The concept of the integral is developed by use of the concept of the limit together with that of the step function. Also included in this semester is a further study of linear programming and of expectation and Markov chains in probability.

Upon completion of Unified Mathematics, Course 5-B, the student should be able to:

- evaluate the derivative of a function implicity
- determine the equation of the lines tangent and normal to a function at a point
- construct solutions to problems involving instanteous rates of change
- determine the monotonicity of a function F on an interval (a, b) by using the value of $F'(x)$ for x in (a,b)
- determine both local and global maxima and minima values and points of inflection of a function F, over any subset of its domain; particularly, to use the Second Derivative Test to determine local maxima or minima
- construct solution to problems involving the maximizing or minimizing of a quantity, subject to given constraints
- apply Rolles Theorem and the Mean Value Theorem

- describe a linear mapping as a structure-preserving mapping between two vector spaces
- give geometric interpretation to linear mapping, their ranges, and kernels
- apply the exchange pivoting algorithm
- apply the simplex method to solve linear programming problems
- recognize a Bernoulli experiment
- compute the probabilities for the various possible outcomes of n independent trials of a Bernoulli experiment
- calculate the expectation of variable X, Y, using formulas E(cX) = cE (X) and E (X+Y) = E(Y), where c is constant
- describe a Markov chain
- identify and compute Riemann integrals
- apply the Fundamental Theorem of Calculus to evaluate definite integrals
- evaluate indefinite integrals with the aid of substitution
- apply the definite integral to solve problems involving area, velocity, or acceleration

Unified Mathematics, Course 6 — Grade 12
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 5
3022 1 year 1 credit

Unified Mathematics, Course 6-A
Prerequisite: Attainment of the objectives of Unified Mathematics, Course 5
3035 1 semester ½ credit

Unified Mathematics, Course 6, builds on the fundamental notions of continuity, limit, differentiation, and integration which were developed in Unified Mathematics, Course 5. In particular, developed in Course 6-A, are improper integrals; integrals and derivatives of exponential functions, logarithmic and trigonometric functions; convergence tests for series; conics; and applications of Maclaurin's or Taylor's series expansion theorems.

Upon completion of Unified Mathematics, Course 6-A, the student should be able to:

- evaluate limits at infinity and improper integrals
- evaluate the limits of sequences
- apply L'Hopital's Rule where applicable
- apply the comparison, ratio, and integral tests for convergence to a given series
- determine the foci, directrices, axes of symmetry, etc., given the equation of a conic
- express the equation of a conic in polar form
- differentiate and integrate functions that involve $\log_a x$, a^x, $\ln x$, e^x, and sums, products, and composites involving these functions
- apply the derivative and integral to problems involving the differential equation $y = Kx$, such as in radioactive decay or population growth
- calculate derivatives for sin, cos, tan, csc, cot, sec, arc sin, arc cos, arc tan, and the variations of these that result from algebraic operations and composition
- calculate antiderivatives for simple circular functions and their inverse
- compute an approximation to the value of given trigonometric or logarithmic functions using Maclaurin's or Taylor's series expansion theorems

Unified Mathematics, Course 6-B
Prerequisite: Attainmen of the objectives of Unified Mathematics, Course 6-A
3037 1 semester ½ credit

In Unified Mathematics 6-B, various integration techniques are investigated in detail. Also the definite integral is used as an application in problems involving velocity, acceleration, volume, surface area, mass, and work. Solutions and applications to some differential equations are considered. Probability concepts are extended to include infinite outcome sets, using the integral in probability calculations. The course and program ends with an intensive, individual study of one of the units in statistics, abstract algebra, geometric transformations, determinants and matrices, or differential equations.

Upon completion of Unified Mathematics, Course 6-B, the student should be able to:

- apply the following integration techniques: substitution by change in variable, integration by parts, trigonometric substitution, integration by partial fractions
- determine the derivative of powers of trigonometric functions
- apply the definite integral to solve problems involving area; velocity and acceleration; volume of a solid; area of surface of revolution; total amount of mass; and work as a product of a given force moved through a given distance
- solve first order differential equations and second order linear differential equations
- describe and identify experiments which have infinite probability spaces
- distinguish between discrete, infinite probability space and interval outcome set
- construct the solution to problems involving the use of the probability density functions and distribution functions
- apply general problem-solving strategies
- complete an intensive study of one of the following units: statistical inference, algebraic structures, geometric transformations, determinants and matrices.

Mathematics 9 — Grade 9
3009 1 year 1 credit

Mathematics 9-A
3015 1 semester ½ credit

Mathematics 9 is a general mathematics course in which the mastery of the skills and understandings of the program for general Mathematics 7 and 8 is completed. The student outcomes are the same as those listed previously for Pre-Algebra Mathematics, Levels O-R (Grades 7 and 8). Students who are identified upon entry into this course as having marked deficiencies in the basic skills will be provided a remedial program. This program will consist of activities designed to help the student acquire the skills necessary for an acceptable level of performance.

Applications of Mathematics — Grade 10
3210 1 year 1 credit

Applications of Mathematics A
3221 1 semester ½ credit

Applications of Mathematics B
3222 1 semester ½ credit

Applications of Mathematics is designed to meet the needs of those students who have not satisfactorily completed Algebra 1 or Algebra 1, Part I. The purpose underlying both semesters of Applications of Mathematics is to provide senior high school students with an opportunity to increase proficiency in

basic skills in mathematics. This purpose can be more specifically defined as progress on the achievement of pre-algebra objectives, as delineated in *Elementary and Pre-Algebra Mathematics Objectives*, with emphasis on the attainment of the *MSDE Functional Mathematics Objectives.*

These basic skills may be delineated as the ability of the student to:

- read and write numerals through nine places
- add and subtract vertically and horizontally through five digits with regrouping
- check multiplication and division problems using three- and four-digit numbers
- add, subtract, multiply, and divide rational numbers in fractional form
- name the greatest common factor and the least common multiple of two or more numbers
- demonstrate decimal fraction notation to three places as an extension of place value
- write decimal fractions for common fractions and vice versa
- add, subtract, multiply, and divide rational numbers in decimal form
- match equivalents of percents, common fractions, and decimal fractions
- convert a percent to a decimal fraction and vice versa
- express comparison as ratios and percents

Activity formats through which students can work to attain skills are suggested as follows:

Semester 1 activities include the use of computing aids and devices; simple equations; formulas; basic geometric techniques; various measuring devices; and metric and customary systems of measure.

Semester 2 activities include those involving purchasing; employment; transportation; hobbies; sampling; statistics; probability; and sequences.

Related Mathematics — Grades 10, 11, 12
3211 — 1 year — 1 credit

Related Mathematics A
3231 — 1 semester — ½ credit

Related Mathematics B
3232 — 1 semester — ½ credit

This course is designed to provide essential mathematical concepts and skills for students whose main interests lie in the shop, home arts, and technical programs. In addition to developing basic computational and measurement concepts, reinforcement of the related skills is provided through the study of automotive, building trade, manufacturing, or other vocational activities. The mathematics experiences in this course borrow heavily from laboratory experiences involving student activity with measuring devices and industrial materials. This "hands on" approach attempts to approximate the situations these students will meet in their chosen work.

The mathematics teacher, having broad knowledge of mathematical principles and techniques, brings to the skill trades a competency and literacy in applied quantitative problems. Furthermore, the mathematics teacher has an excellent situation within which to answer the question so often asked by students, "What is mathematics good for?"

Upon completion of Related Mathematics, the student should be able to:

- compute with whole numbers, common fractions, decimals, and percents
- interpret a scale drawing
- use and read various measurement devices

- calculate perimeters, areas, and volumes peculiar to the vocational areas in which the student is interested
- find squares and square roots for given numbers
- complete various business order forms
- compute the costs for various home management, auto, building, and manufacturing problems or projects
- solve problems related to the vocational areas in which the student is interested

Consumer Mathematics — Grades 11, 12
3212 1 year 1 credit

This course is available to all Grade 11 and Grade 12 students, regardless of their preparation. Consumer Mathematics combines a course in consumer education with a course in the mathematics necessary to make wise consumer decisions. Standard text material is supplemented by materials from the daily newspapers, consumer magazines, and federal publications to keep content relevant to the needs of the student.

Consumer Mathematics A
3241 1 semester ½ credit

The topics investigated in Consumer Mathematics A include wise consumer decisions; interpreting data; buying food, clothing, and appliances; budgeting time and money; credit; and banking.

Upon completion of Consumer Mathematics A, the student should be able to:

- recognize consumer rights and responsibilities
- identify and analyze those factors in a consumer situation which should be considered prior to making a decision
- make wise decisions on consumer purchases through the use of government publications and independent consumer research literature
- analyze labels, brands, grades, sizes, prices, and other guides for comparative and economical buying of food, clothing, furniture, and appliances
- develop an understanding of the need for financial planning in the areas of food, clothing, furniture, and appliances
- recognize the role played by personal values, goals, wants, and needs in the area of money management
- construct budgets for given situations
- analyze the cost of consumer credit
- compare consumer credit services offered by various lending agencies
- demonstrate an ability to manage various personal financial accounts
- compare the banking services of various kinds of financial institutions

Consumer Mathematics B
3242 1 semester ½ credit

The topics investigated in Consumer Mathematics B include taxation, investments, personal transportation, insurance, housing, and travel.

Upon completion of Consumer Mathematics B, the student should be able to:

- display a basic understanding of the opportunities available through investments to make money work for the individual
- describe various types of investments available to the individual

- recognize the role that taxes play in our society
- prepare accurate tax returns
- determine the factors involved in the need for personal transportation
- analyze the factors necessary to consider in purchasing and ordering a vehicle
- describe the benefits and costs of various types of insurance available
- determine the type of insurance coverage needed to meet specific needs
- identify the factors to be considered when determining whether to buy or to rent a house
- compare the costs of owning and renting a house or apartment
- recognize factors to be considered when one decides to travel
- compare several travel plans

Single-Semester Courses — Grades 11, 12

1 semester ½ credit each

Upon completion of Algebra 2, students may elect one or more short-term courses. The current list of such courses includes those which follow, each intended as a semester offering:

3411 Trigonometry
3412 Advanced Algebra
3421 Elementary Functions
3422 Analytic Geometry
3413 Probability and Statistics
3414 Matrices
3415 Mathematics in Our Culture
3416 Computer Mathematics

Each individual school will need to determine (after considering available staff, student needs and interests, scheduling capabilities, and school organization) to what degree such choices can be implemented. In some schools, any of the listed short-term courses may be elected at appropriate times by students having the necessary background; in other schools, only selected short-term courses might be made available; while in still other schools, it may be necessary to combine selected short-term courses and offer them as one or more year-long courses. As an example, a school in which it is determined that semester or other short-term possibilities are not feasible could combine Trigonometry and Advanced Algebra as a single, year-long course; and Elementary Functions and Analytic Geometry could be combined into an Introductory Analysis course. Other combinations are possible to match the needs and interests of the students. This type of organization at this level is intended to afford greater flexibility in providing programs of significance to the mathematically able students. Additional short-term courses, as they are developed locally or at the county level and approved by the Council on Instruction, may be included at later dates.

The Elementary Functions and Analytic Geometry courses are a required combination for those students who plan to study Calculus in high school. Students not planning to study Calculus may choose either one of these two courses if offered by their school.

The prerequisites for each of the listed short-term courses will vary, but all require completion of Algebra 2. There is no prescribed sequence among the courses; and any combination is instructionally possible, provided the student has completed the indicated prerequisites.

Trigonometry — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3411 1 semester ½ credit

The solution of triangles and the practical applications of trigonometry to surveying, navigation, and other physical measurement is included; but the major emphasis in trigonometry is algebraic. The trigonometric functions are treated as circular functions; algebraic manipulations of their fundamental identities and solutions of trigonometric equations are emphasized as they would be used in mathematics, physics, and engineering.

Upon completion of Trigonometry, the student should be able to:

- apply the relationships of the integral multiples of $\frac{\pi}{6}, \frac{\pi}{4}$ (30°, 45° angles) to the solution of trigonometric equations
- apply the fundamental trigonometric relations to verify identities
- evaluate functions of angles, using a table, interpolating as necessary
- solve problems involving angular measure expressed in radians
- sketch the graphs of simple and composite trigonometric functions and of the corresponding inverse relations
- apply the fundamental relations of composite angles to prove equations to be identities
- apply the trigonometric functions to the solution of problems
- apply the properties of logarithms, and use log tables to solve various triangles
- apply the laws of sines, cosines, and tangents to the solution of oblique triangles
- solve trigonometric equations
- solve equations involving inverse trigonometric functions
- apply De Moivre's Theorem

Advanced Algebra — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3412 1 semester ½ credit

This course provides the student with a fifth semester of algebra and prepares him/her for further work in mathematics and related fields of study. It includes topics that were formerly included in such college-level courses as College Algebra or Theory of Equations.

Included are an analytical development of the numbers system through the complex numbers; mathematical induction; the solution of polynomial equations and inequalities; polynomial, rational, and algebraic functions; the Remainder Theorem, Factor Theorem, and synthetic division; finding the rational, real, or complex roots of various polynomial equations; polar representations of complex numbers; binomial theorem; sequences and series; exponential and logarithmic functions; basic counting theory and probability; and variations.

Upon completion of Advanced Algebra, the student should be able to:

- apply the fundamental operations of algebra to the solution of problems involving linear and quadratic equations
- add, subtract, multiply, and divide expressions containing radicals
- sketch the graphs and estimate the zeros of polynomial functions
- apply the simultaneous solution of systems of equations in two and three unknowns to word problems
- apply curve sketching techniques to the graphical solution of sets of quadratic equations
- solve algebraically systems of equations of the type $Ax^2 + Bxy + Cy^2 + Dx + Ey = F$
- apply DeMoivre's Theorem to find roots of complex numbers

- solve polynomial inequalities
- write the equation for the inverse of a given function
- sketch exponential and logarithmic functions
- solve exponential and logarithmic equations
- solve word problems involving arithmetic, geometric, and harmonic progressions
- expand binomials by use of the binomial formula
- compute the probabilities of events in a finite sample space

Elementary Functions — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3421 1 semester ½ credit

The objectives for the course are delineated in the course description for the Elementary Functions/Analytic Geometry. (See pp. 8-9.)

Analytic Geometry — Grades 11, 12
Prerequisite: Attainment of the objectves of Algebra 2
3422 1 semester ½ credit

The objectives for the course are delineated in the course description for Elementary Functions/Analytic Geometry. (See pp. 8-9)

Probability and Statistics — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3413 1 semester ½ credit

The study of the theory of Probability attracts students for a number of reasons. Some find beauty in the mathematical structure; others enjoy discussing the meanings that may be attached to probabilistic statements; still others admire the order emerging from chaos — a given event may not be predictable. Probability is the basis for mathematical models of situations in social science and science as well as in mathematics. It forms a basis for, and is supplemented by, statistical inference. Statistics is the art and science of gathering, analyzing, and making inferences from data. Using the theorems of probability as tools, statistical hypotheses are tested and predictions for "success" are made.

This course will prove to be especially appropriate for college-bound students with interests outside the mathematics/science disciplines, yet who will encounter college statistics courses and research projects.

Upon completion of Probability and Statistics, the student should be able to:

- construct a frequency distribution of the results of a given experiment
- distinguish between *a priori* and *a posteriori* probabilities
- apply the methods of counting to determine the number of possible outcomes for given situations
- compute the probabilities of given events
- apply random sampling selections to the determination of probabilities
- apply the measures of central tendency and dispersions to interpret statistical data

Matrices — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3414 1 semester ½ credit

Elementary matrix algebra is an integral part of the mathematical background of the physical, biological, and social sciences as well as of statistics and pure mathematics. The advent of the computer, combined with matrix algebra, has made possible the solution of problems in linear programming involving the solution of sets of equations in a number of unknowns.

The manipulative skill required for using matrices in their numerous applications is neither great nor excessively demanding; but in terms of brevity, simplicity, and clarity, the value of matrix algebra is often considerable. The universal nature of matrix expressions results in their application both to situations involving small amounts of data and to those involving extremely large amounts. Both the acquisition of the manipulative skill to work with matrices and the applications of matrices to problem solving in fields other than mathematics are included in Matrices.

Upon completion of Matrices, the student should be able to:

- identify the basic properties of matrices
- demonstrate the algebraic properties of matrices
- construct the inverse of a given matrix, if it exists
- apply the techniques of matrix algebra to the solving of systems of equations
- apply matrix multiplication to the transformation of lines in the plane by reflection, translation, and rotation
- construct a characteristic equation for a square matrix
- construct the eigenvectors for a given matrix
- demonstrate the Cayley-Hamilton Theorems for a given matrix
- apply matrix methods to the solution of problems of applied mathematics

Mathematics in Our Culture — Grades 11, 12
Prerequisite: Attainment of the objectives of Algebra 2
3415 1 semester ½ credit

This semester course is intended for the student who has done well in mathematics but who questions its value to the nonmathematician. The course will motivate the student to study mathematics, particularly the historical development of mathematics and the applications of mathematics in life situations, especially those that are unlikely and uncommon. The primary goal of the course is to enhance the student's appreciation of mathematics as a vital element in our culture through an exploration of its impact upon society. The content studied can vary from our number system to topology. Highlights of the historical development of mathematics, the lives of famous mathematicians, famous problems and puzzles, and interesting and unusual applications are examined.

Upon completion of Mathematics in Our Culture, the student should be able to:

- describe the ways in which mathematics has contributed to world cultures throughout history
- name and describe applications of mathematics in life situations today
- identify and describe famous mathematical problems and puzzles

Computer Mathematics — Grades 11, 12

3416 1 semester ½ credit

Industry, the business world, and most colleges and universities are utilizing the power of the computer more and more, especially through remote terminals and time sharing. Our own area is rich with research and development industries which depend heavily upon the computer. Computer programming, problem solving, and the teaching of mathematics have a great affinity for each other and are mutually supportive. For these reasons, many students will find this course desirable, interesting, and rewarding. Among the topics of study are problem definition and flowcharting techniques; a computer programming language; writing programs for mathematics problems commensurate with the background of the student; error diagnosis; and program documentation. Students will write and debug their own programs which will be run on a computer through the means available to the individual school. They will be able to explore mathematical problems which are too time-consuming or otherwise not feasible for ordinary classroom study.

Upon completion of Computer Mathematics, the student should be able to:

- describe the functions of a computer and its peripheral equipment
- construct a flowchart for a given mathematics problem, commensurate with his/her background
- write a minimum of ten programs of increasing difficulty, commensurate with his/her background
- execute these programs and debug them if necessary
- provide documentation for at least one program, including all information needed by another user of the program

MCPS INSTRUCTIONAL GUIDES — MATHEMATICS 9-12

Elementary and Pre-Algebra Mathematics Objectives, Bulletin No. 285, 1975.
Course of Study for Geometry, Bulletin No. 261, 1972.
Consumer Mathematics Instructional Guide, 1977.
Calculus Instructional Guide, 1978.

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